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STAGE 2 HYDROPOWER STUDY: CAGLES MILL LAKE, INDIANA.(U)
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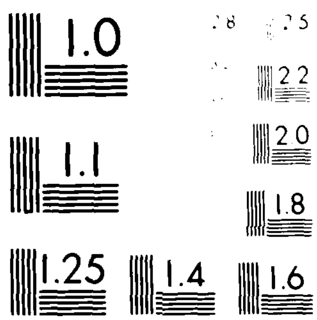
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The principle planning objective was the development of a renewable resource energy production facility for Cagles Mill Lake and the surrounding study area to be of benefit for a 100-year period of analysis.

All plans studied are economically infeasible due primarily to the cost of the conveyance system needed to deliver the water to the powerhouse. The maximum capability of a house power unit in the center gate opening of the control tower is almost 250 KW. (over)

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It is recommended that the study of the feasibility of small scale hydropower at Cagles Mill Lake, Indiana be terminated.

It is recommended that a small station power unit, having an installed capacity of about 250 KW, be designed and installed in the existing tower at the earliest possible date to provide power for project facilities.

STAGE 2 HYDROPOWER STUDY

CAGLES MILL LAKE, INDIANA

Prepared by
U.S. Army Engineer District, Louisville

July 1981

STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

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STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INTRODUCTION

The recent focus on our national energy resources has generated significant renewed interest in hydroelectric power development at new as well as existing projects. Hydropower plants have proven to be clean, safe, efficient, reliable and economically attractive. This study was undertaken to examine and assess the social, economic, environmental and institutional factors influencing its development at Cagles Mill Lake, Indiana.

AUTHORITIES

PROJECT AUTHORIZATION

Cagles Mill Lake was authorized for construction under the general authorization for flood control in the Ohio River Basin contained in the Flood Control Act of 28 June 1938 (Public Law No. 761, 75th Congress, 3rd Session). The development of Cagles Mill Lake for recreational purposes was accomplished under general authority of Section 4 of the Flood Control Act of 1944 (Public Law 534) as amended by the Flood Control Act of 1946 (Public Law 526). Construction of the project was started in July 1948 and was completed in June 1953.

STUDY AUTHORIZATION

The authority for the hydropower evaluation study of Cagles Mill Lake is Section 216 of the Flood Control Act of 1970. The study was initiated during Fiscal Year 1976 on Advice of Allotment dated 2 February 1976 to identify those problems and conditions associated with the operation of the project that might require Congressional action for resolution. The Section 216 study was extended by 1st Indorsement to the Louisville District's letter of 29 June 1979

requesting extension to evaluate the feasibility of adding hydropower facilities at the project.

PROJECT DESCRIPTION

LOCATION AND PURPOSE

Cagles Mill Lake is located in rural Putnam and Owen Counties, Indiana, 2.8 miles above the mouth of Mill Creek, a tributary of the Eel River, about 25 miles east of Terre Haute and about 40 miles southwest of Indianapolis, Indiana (see Exhibit 1). The surrounding area consists of small farms and woodlots as the Mill Creek Basin is located in relatively rugged terrain. The native hardwood slopes and Cataract Falls, the largest falls in Indiana, accent the attractiveness of the lake to visitors. The project is described further in project data sheets included as Exhibit 2.

FLOOD CONTROL FEATURES

For normal operations, the lake is maintained at or as near as possible to elevation 636 feet above the national geodetic vertical datum (NGVD), which maintains a 1,400-acre lake. At full flood control pool, elevation 704, the lake covers some 4,840 acres with total capacity of 201,000 acre-feet of storage. The flood storage capacity is equal to 12.78 inches of runoff from the 295 square miles of contributing drainage area upstream from the dam. The fee taking line was established at elevation 704 and the top of the dam is at elevation 730.

RECREATIONAL FEATURES

About 8,200 acres of state and Federal lands are presently available for recreation and fish and wildlife use in the Cagles Mill Lake vicinity. The Louisville District, Corps of Engineers, leases about 7,100 acres to the state and manages a 145-acre site by the dam.

The remaining land is owned by the state and is located in Lieber State Park and the Cunot recreation site. Recreational sites along with facilities available at each site are presented in Table 1. See Exhibit 2 for site locations.

PROJECT ACCOMPLISHMENT

Benefits accruing to Cagles Mill Lake for flood control operations amounted to $25,385,000 as 30 September 1980, averaging about $906,600 per year. In regard to recreation, total project visitation as of 31 December 1980 amounted to 7,805,300, averaging 289,100 per year. Peak year for flood damages prevented was 1979 with $3,237,000. Recreational visitation reached a record high in 1976 with a total of 440,700.

STUDY OBJECTIVES AND CONSTRAINTS

OBJECTIVES

Two groups of objectives were utilized in the course of this study including national objectives and project-specific planning objectives while one group of constraints was utilized.

National Objectives - The two major objectives to be addressed in the study and/or development of water and related land resources are the National Economic Development (NED) and Environmental Quality (EQ) objectives. Alternatives were selected and to give individual attention to each of these objectives.

Planning Objectives - These are project-specific water and related land resource management needs. The principal planning objective was the development of a renewable resource energy production facility for Cagles Mill Lake and the surrounding study area to be of benefit for a 100-year period of analysis. Specific aspects of this overall objective are shown below:

Provide for energy production from a renewable resource; and

Reduce dependence on nonrenewable foreign and domestic fossil fuels.

PLANNING CONSTRAINTS

The major constraints to be observed in the course of the study are presented below:

Minimize adverse impacts to other project purposes and activities; and,

Minimize adverse impacts to the environment.

The major constraint utilized in the evaluation of hydropower operations and energy production was the use of the project for flood control operations. This would occur during periods of high runoff when outflows would be cut back to store potentially damaging flows and power production would be stopped. After the period of high runoff and flood control storage, outflows would be limited for some time to permit downstream flows to stabilize. Power production would be at a reduced level or stopped until flows at downstream control stations began to recede. This study constraint takes the form, in regard to flood control, that the combination of storage allocated to hydropower and the plan of power and non-power releases should not cause any spillway flood events additional to the number caused by the existing reservoir regulation plan. Table 2 presents the selected ranges of various study and design parameters utilized in the hydropower analysis.

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ANALYSIS OF HYDROPOWER POTENTIAL

Alternatives were formulated to span the range of opportunities for adding hydropower facilities at Cagles Mill Lake. The analysis was done in a straightforward manner, beginning with the selection of representative hydropower storage regimes.

STORAGE ALLOCATION

The hydropower storage regimes selected range from the existing reservoir regulation plan with the addition of generating equipment to a 100 percent hydropower storage utilization plan. The plans are itemized in Table 3 and detailed below.

Hydropower Plan No. 1 - This plan would provide for the installation of penstocks, power house and appurtenances necesary for power generation but would not reallocate any flood control storage to the hydropower purpose, relying instead on inflows for generation. Such flows can be of significant magnitude although random in volume and occurrence.

Plan No. 2 - This plan requires reallocation of storage to the hydropower purpose by establishing a power pool between Elevations 636 and 655. This provides about 34,400 acre-feet (AF) for hydropower purposes. It would reduce designated flood control storage by 17 percent from 201,000 AF to 166,565 AF. Plans No. 1 and 2 were also evaluated with a ten foot higher seasonal pool which would increase the rated head at the turbine and also mitigate some of the adverse effects on recreation.

Plan No. 3 - This plan utilizes a power pool between Elevation 644 and 685 but without a seasonal increase variation. Power storage would be about 108,000 AF, reducing flood control storage by 60 percent to 80,400 AF. Storage below Elevation 644 amounting to 12,600 AF would become dead storage.

Other Hydropower Plans - Two additional plans were formulated early in the analysis. Plan 4 called for a power pool between Elevations 658 and 689 while Plan 5 called for total reallocation of project storage to hydropower with a power pool set between Elevations 668 and 704, the existing spillway elevation. As work progressed, it was evident that certain variations of Plan 3 produced a significant number of additional spillway events. Therefore, Plans No. 4 and 5 were dropped from further consideration as not complying with stated planning objectives and constraints.

The above plans were analyzed in a matrix format which varied the installed capacity (IC), time on peak (TOP) and other evaluative aspects to optimize energy production. The energy optimization effort was followed by conveyance system and power house sizing to set the stage for cost and benefit analysis. See Table 3.

CONVEYANCE SYSTEMS

Formulation of conveyance system-powerhouse requirements included several options. Five storage regimes were originally formulated but only three were considered practicable to estimate. The fourth and fifth were not estimated due to problems with acceptability, constructibility and expected high cost. The conveyance-powerhouse opportunities included the following methods.

Modification to the Existing Outlet Works - With these existing facilities, it would be necessary to line the conduit with steel plate to provide the pressure capability required for hydropower use. Overall estimates were prepared for three power plant capacities: 1.0, 3.5 and 7.5 megawatts (MW). The 7.5 MW size is the maximum capability for the modifed conduit without exceeding a 10 feet per second (FPS) design velocity limit. Modifications to the tower would include provisions for selective withdrawal to provide temperature control. The powerhouse would be located in the tailwater area with appurtenances such as

penstock, switch gear, tailrace access road and parking area. Using the existing conduit will require an intake structure with sluice gates above the existing stilling basin, necessitating a new outlet structure. Penstocks connecting the conduit to the powerhouse would be through an open cut. Vertical Francis turbines would be used. A layout of this plan is shown on Plate 2 while a profile through the outlet works is shown on Plate 3.

Alternate Conveyance System - A second method would utilize an 11-foot diameter tunnel bored through the right abutment for supplying water to the powerhouse. With a grouted in place steel plate lining, the tunnel should withstand the pressures expected during hydropower operations. A tunnel conveyance system will require a new intake structure which would be equipped for selective withdrawal and a sluice gate at the upstream end. Penstocks would connect the tunnel to the powerhouse. Cost estimates were prepared for this general layout sized at 3.5 MW. The Plan B layout and profile are shown on Plates 4 and 5.

Existing Tower Unit - The existing intake tower was evaluated to determine the maximum size of a turbine/generator unit that could be installed without major structural modification. Since Cagles Mill has only one 30 inch low flow bypass, that was not considered a real opportunity. Cagles Mill Lake has three gate openings in the tower. The center gate is not used. The center gate could be replaced by a right angle drive type turbine with the drive shaft passing through the existing gate stem opening to the generator. Or, a self-contained bulb turbine unit could be installed and the center gate used as the control gate. A weir would be constructed in the center gate bay area to provide the tailwater elevation required by the turbine. The above installation is estimated to cost about $350,000 providing about 250 kilowatts (KW) of power with 60 feet of head and 60 cfs flow. This is seen as the maximum development feasible utilizing the exsiting tower without major modification.

Upstream Powerhouse - With this plan, the powerhouse with intake would be built in the upstream dam fill. A similar plan was evaluated for Wm. H. Harsha (East Fork) Lake using a powerhouse located directly over the conduit. The conduit could then serve as the tailrace. This was the most expensive conveyance system investigated for Harsha Lake. At Cagles Mill, the dam embankment is dumped stone with 2H to 1V side slopes. Also, the service bridge is situated directly above the conduit. It was apparent that the basic cost for this plan would be very expensive as formulated, even more expensive if it were necessary to move the powerhouse to the side to avoid the tower service bridge or to move the bridge. Detailed estimating was not done for this plan.

Selected Conveyance - Plan A, conduit lining, was selected as the system of choice, primarily because of economics. A separate conveyance system would provide considerably greater design freedom and system operational flexibility. However, comparative estimates of conduit lining versus a new tunnel for the 3.5 MW installed capacity indicated the tunnel method to cost about $1,380,000 more than the conduit lining method, a 19 percent increase. See Table 4.

TURBINE SELECTION

Kaplan or Francis turbines could be used effectively at Cagles Mill Lake. Available head for most plans, however, is at the lower end of useability for a Francis machine. District experience with Francis installations led to the use of a Francis turbine for estimating purposes. The unit would have adjustable wicket gates. Cost differential between the two type units is considered small; a Kaplan would require additional excavation in rock; a Francis requires a larger powerhouse area. Estimates of costs and average annual energy are based on a one-unit installation. The powerhouse and appurtenant facilities would be designed to permit discharge of large volumes of water to evacuate flood storages, as needed, thus maintaining flood control capability.

COST ESTIMATES

Cost determinations were made for the plans and facilities outlined above for various installed capacities in terms of total first costs and average annual costs.

First Costs - Cost estimates for the various plans and variations were prepared using the following major categories:

- Conveyance system
- Turbine, generator and governor
- Powerhouse structure
- Powerhouse equipment
- Switchyard
- Sitework
- Tailrace
- Miscellaneous Electrical Equipment
- Contingencies
- Engineering and Design
- Supervision and Administration

The conveyance systems costs were determined using preliminary quantity takeoffs from the conceptual layouts and project "As Built" drawings of the Cagles Mill Lake outlet works. The HEC/IWR Guide Manual for feasibility studies of small scale hydropower facilities was used when possible for costing data. The powerhouse structure costs were based on quantity takeoffs for an outdoor-type layout. Turbine, generator and governor costs came principally from the HEC/IWR manual, updated to currrent price levels. Sitework costs include the tailwater access road and parking lot reconstruction. Tailrace costs were derived from costs of excavation in rock from the powerhouse to the stream channel. Miscellaneous costs are related to powerhouse, turbine, generator and switchyard costs. They include an allowance for switching gear and control systems for a remotely controlled powerhouse.

Contingencies amounting to 25 percent of all facilities costs were included to cover those lesser items not given detailed analysis. Transmission costs are based on a three-mile tie in line to existing powerline facilities. Lake area/pool preparation costs were prepared for each storage regime recognizing limited tree cover below Elevation 645; clearing limits would be three feet below design minimum to two feet above design maximum; no miscellaneous clearing would be necessary; and finally, all stumps and debris would be burned on site. Costs to modify or replace existing recreational facilities were estimated for each storage regime. It was determined that there would be little or no requirements for additional project real estate needs. Table 5 is a cost summary for all plans and installed capacities evaluated in detail.

Average Annual Costs - To develop the average annual costs, interest during construction was added to total project first costs (TFC). Two construction seasons were assumed adequate for the project. An interest rate of 7 3/8 percent was applied against the TFC for two seasons to determine project investment costs. The following factors were utilized in the computation of average annual costs:

Interest and amortization were computed at 7 3/8 percent for an economic project life of 50 years;

Operation and maintenance amounting to 1.2 percent of the investment cost was included, consistent with the HEC/IWR manual.

Major replacement estimated at 0.1 percent of the investment costs was added for this portion of overall annual costs.

Annual costs for all plans are summarized in Table 6.

ENERGY PRODUCTION

Sequential analyses were performed to determine the energy production capability of the project for a range of installed capacities for each storage regime.

Energy Determinations - The basic equation used to determine energy production in a hydropower analysis is:

$$\text{Daily Energy (Kwh/day)} = \frac{E \times H \times Q \times 24 \text{ hrs}}{11.8}$$

Where E is the efficiency of the turbine/generator unit, H is head and Q is the discharge through the turbine(s). Pre-project and post-project rainfall, runoff, discharges and holdouts were reconstituted to natural flows to be analyzed by computer. Downstream control station data are incorporated to indicate when flooding is occurring such that the reservoir should begin flood control operations. If the reservoir is in a flood control operation (Schedule C or D), no power is computed for that day to insure that power generation does not impact on the reservoir's flood control purpose. As noted in the above equation, the major factor affecting energy production for a given project is the Q or flow through the turbines. Cagles Mill Lake, with a drainage basin of 295 square miles, has an average flow slightly over 300 cfs or about 1 cfs per square mile of drainage area. After the constraints have been applied to every daily value of discharge, head, and energy, a daily energy duration analysis is performed and printed as output. The final step in the analysis is converting the duration table to an average annual energy by determining the area under the duration curve. Average annual energy for the various storage regimes and installed capacities is summarized on Table 7.

Dependable Capacity - Dependable capacity, defined as that capacity available 90 percent of the time during peak load, was determined by evaluating the project's capacity duration data. The data available

from daily analysis were verified by monthly flow data and RESOP program results. Dependable capacity during summer peak periods is insignificant. Dependable capacity during winter peak periods is small, varying with time on peak and storage regime. Table 8 summarizes the dependable capacity analysis by storage regime for the selected winter peak, assumed to occur in the month of January.

BENEFITS

Analysis of benefits to a hydropower project requires a selection of a most likely alternative. Monetary values are then assigned to the average annual energy and dependable capacity of the hydropower facility.

Power Values - Regional power values for ECAR initially developed by the Federal Energy Regulatory Commission (FERC), updated to July 1981 price levels, have been used. These values are presented in Table 9. Updated values include adjustment for fuel cost escalation as allowed by the Principles and Standards and by Department of Energy procedures. Appropriate values are determined by selecting the most likely alternative to a hydropower plant with selection based on capacity factors. For the Cagles Mill project, a small combustion turbine generating unit is considered the most likely alternative. The operational parameters established for the hydropower facility and its relatively small size are best matched or compared to a combustion turbine unit.

Benefit Computations - Annual power benefits are derived by combining appropriate power values with averge annual energy and dependable capacity. These benefits are displayed in Tables 10 through 14 for the NED, EQ and Trade Off operations for the storage regimes evaluated. The tower unit (250 KW) is too small to consider using the regional type economic analysis described in the foregoing pages. An installation of this size would be considered a house power unit and would generate only for project use.

Economic Comparisons - Average annual costs (AAC) are compared to average annual benefits (AAB) in Tables 15 through 19. (AAB are from Tables 10 through 14 while AAC is from Table 6.) No plan evaluated in the study develops average annual benefits greater than average annual costs, that is, positive net benefits. For Plan 2 with four-hour NED operation, optimum economics are realized with an installed capacity of 6 MW. All other cases optimize with a 4 MW unit. The following comparisons can be made.

It can be observed from the net benefit results tabulated that the lack of economic feasibility is due to the significant cost of the power facilities. The increase in capacity from 1.0 MW to 4 MW reduces the deficit of benefits, indicating that these installed capacities - up to 4 MW - would be incrementally justified if the initial cost of the conveyance facilities, etc., could be justified.

On the other hand, if it is assumed that all power related costs form a basic investment that must be made to incorporate hydropower as a project purpose, then the high cost of modifying and/or replacing existing recreational facilities would be the actual block of costs that cannot be fully supported by project hydropower benefits. The point to be made is that hydropower could be made economically feasible if recreational replacement costs could be reduced. This would mean a level of facilities replacement other than full replacement. To evaluate this, a test was made of various levels of recreation facility replacement: full replacement, half replacement and zero replacement. All data tabulated in the report includes full replacement. The test was applied to Plan 1A with optimum capacity (4.0 MW) and maximum capacity (7.5 MW) in Plan 1. Plan 1A is basically the same but with a ten foot seasonal increase. As might be expected, avoidance of part or all of the recreation facilities costs raised the BCR's and reduced the mills per kilowatt production costs. However, in neither case did

avoidance of any or all of these costs raise the BCR's above 0.80. Also, non-replacement of such facilities would have disbenefits associated with lost recreational visitation. Due to the unfavorable BCR's no additional effort was made to determine the magnitude of these disbenefits. Such a tradeoff is not one considered capable of drawing widespread support, especially with the general public. Also, such a means of justifying hydropower by conversion would offer no financial means to compensate for the recreational facilities lost. In essence then, the addition of hydropower at Cagles Mill Lake is economically infeasible when evaluated and tested against basic study objectives.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The following conclusions are made as a result of this study.

All plans studied are economically infeasible by a wide margin;

Alternative study parameters and storage regimes developed within the operational constraints of the existing project purposes do not significantly affect energy development;

Power facility costs are the most significant factor in economic infeasibility. This is due primarily to the cost of the conveyance system needed to deliver the water to the powerhouse.

The maximum capability of a house power unit in the center gate opening of the control tower is about 250 KW. This station power could be developed without specific Congressional authority provided the energy is not marketed but exchanged for project power purchases which would otherwise be made.

RECOMMENDATIONS

The following recommendations are made as a result of this study.

It is recommended that the study of the feasibility of small scale hydropower at Cagles Mill Lake, Indiana be terminated, as economic feasibility is lacking by a wide margin.

It is recommended that a small station power unit, having an installed capacity of about 250 KW, be designed and installed in the existing tower at the earliest possible date to provide power for project facilities.

Cagles Mill Tables

TABLE 1

PUBLICLY OPERATED RECREATION FACILITIES
CAGLES MILL LAKE, INDIANA

	Recreational Site				
Feature	Damsite	Cunot Ramp	Lieber State Park	Cataract Falls	Project Totals
Operating Agency	Corps	State	State	State	
Acreage	145	60	1,638	180	2,023
Picnic Sites	19	20	950	45	1,034
Campsites	0	0	310	0	310
Launching Ramps	0	1	1	0	2
Launching Lanes	0	8	1	0	9
Mooring	0	0	75	0	75
Swimming Beaches	0	0	1	0	1
Bathhouses	0	0	1	0	1
Cabins or Inns	0	0	0	0	0
Parking Lots	2	2	8	2	14
Car Spaces	262	25	560	102	949
Car-Trailer Spaces	0	171	42	0	213
Paved Roads - Miles	2	1	7	0	10
Unpaved Roads - Miles	0	0	1	1	2

TABLE 2

CAGLES MILL LAKE STREAMLINED HYDRO STUDY
ALTERNATIVE STAGE II OPERATIONAL CONCEPTS

Feature	Units	NED. Max Output		EQ Oriented		Trade-Off	
Period	---	Apr-Sep	Oct-Mar	Apr-Sep	Oct-Mar	Apr-Sep	Oct-Mar
Power Operation							
On Peak							
Time	Hours	4	4	10	10	8	8
Plant Factor	Percent	10	10	40	40	20	20
Off Peak							
Time	Hours	20	20	14	14	16	16
Plant Factor	Percent	70	70	60	60	70	70
Daily Constraints							
Lake Fluctuation	Feet	1	1	0.5	0.5	1	1
Minimum Flow	Cfs	18	0	18	18	18	18
Maximum Flow	Cfs	1800	3000	1800	1800	1800	1800
TWTR. Fluctuation	Feet	3.	5	2	3	3	5
Typical Conditions							
140 Cfs - ADF Max Daily Drawdown = 0.19 ft							
Max Release	Cfs	750	840	310	310	384	384
Min Release	Cfs	18	0	18	18	18	18
Max TWTR Fluct.	Feet	1.7	1.9	1.0	1.0	1.1	1.1
Energy on Peak	Percent	89.3	100	92.3	92.3	91.4	91.4
Capacity Req'd 1/	MW	3.0	3.5	1.2	1.2	1.5	1.5
200 Cfs - ADF Max Daily Drawdown = 0.27 ft							
Max Release	Cfs	1110	1200	455	455	564	564
Min Release	Cfs	18	0	18	18	18	18
Max TWTR Fluct.	Feet	1.9	2.4	1.2	1.2	1.4	1.4
Energy on Peak	Percent	92.5	100	94.8	94.8	94	94
Capacity Req'd 1/	MW	4.3	4.7	1.8	1.8	2.2	2.2
300 Cfs - ADF Max Daily Drawdown = 0.41 ft							
Max Release	Cfs	1710	1800	695	695	864	864
Min Release	Cfs	18	0	18	18	18	18
Max TWTR Fluct.	Feet	2.8	3.0	1.6	1.6	1.8	1.8
Energy on Peak	Percent	95	100	96.5	96.5	96	96
Capacity Req'd 1/	MW	6.6	7.0	2.7	2.7	3.4	3.4

1/ Estimate for Plan 2 only. Varies with storage regime and rated head (Hr).

TABLE 3

HYDROPOWER ALTERNATIVES

PROJECT: CAGLES MILL LAKE HYDROPOWER STUDY STREAM: MILL CREEK

PLAN NO.	MIN. POOL	POOL ELEVATIONS AND PERCENT STORAGE UTILIZATION									STORAGE	
		POWER		PERCENT TOTAL STORAGE	SEASONAL		PERCENT TOTAL STORAGE	FLOOD CONTROL		PERCENT TOTAL STORAGE	POWER	FLOOD CONTROL
		LOWER	UPPER		LOWER	UPPER	2/	LOWER	UPPER		(AC-FT)	(AC-FT)
Existing	636	--	--	--	636	637.5	1.1	636	704	100	--	201,006
1 1/	636	636	--	--	636	646	7.6	636	704	100	Inflows Only	201,006
2 1/	636	636	655	17	655	665	14.3	655	704	83	34,441	166,565
3	644	644	685	60	--	--	--	685	704	40	108,040	80,381
4	658	658	689	67.5	--	--	--	689	704	32.5	94,602	65,268
5	668	668	704	100	--	--	--	--	--	--	134,563	--

NOTES

1/ Plans 1 and 2 will be evaluated with and without a seasonal pool.

2/ Percentages shown are the reductions of maximum available flood control (FC) storage due to the seasonal.

3/ Operational constraints for hydropower plans are as follows: Maximum release - 1,800 cfs; Minimum NED plans; 0.5 foot for EQ plans.

TABLE 4

NEW TUNNEL VS CONDUIT LINING COST COMPARISON
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

Item	Tunnel Lining ($1000)	New Tunnel ($1000)
Modification of Existing Outlet Works	1,304	--
Intake Structure and Tunnel	--	2,150
Penstock	44	44
Powerhouse and Switchyard	1,303	1,303
(a) Structure	(553)	(553)
(b) Equipment	(750)	(750)
Turbine and Generator	1,313	1,313
Sitework/Access Road	259	259
Tailrace	62	62
Miscellaneous	524	608
Subtotal	4,814	5,739
Contingencies	1,204	1,430
Subtotal	6,018	7,169
Engineering and Design, Supervision and Administration	1,202	1,431
TOTAL	7,220	8,600

TABLE 5

SUMMARY OF TOTAL FIRST COSTS -- ALL PLANS
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

PLAN	INSTALLED CAPACITY (MW)	LAKE AND POOL PREPARATION	POWER FACILITIES	TRANSMISSION FACILITIES	RECREATION FACILITIES MODS	TOTAL PROJECT FIRST COST	COST PER INSTALLED KW
1	1.	--	$4,595	$197	$ --	$4,792	$4,792
	2.	--	5,680	204	--	5,884	2,942
	4.	--	7,650	218	--	7,868	1,967
	6.	--	9,240	235	--	9,475	1,579
	7.5	--	9,900	246	--	10,146	1,353
1A	1.	240	4,595	197	2,134	7,166	166
	2.	240	5,680	204	2,134	8,258	4,129
	4.	240	7,650	218	2,134	10,242	2,560
	6.	240	9,240	235	2,134	11,849	1,975
	7.5	240	9,900	246	2,134	12,520	1,669
2	1.	860	4,595	197	3,686	9,338	9,338
	2.	860	5,680	204	3,686	10,430	5,215
	4.	860	7,650	218	3,686	12,414	3,103
	6.	860	9,240	235	3,686	14,021	2,337
	7.5	860	9,900	246	3,686	14,692	1,959
2A	1.	1,560	4,595	197	4,948	11,300	11,300
	2.	1,560	5,680	204	4,948	12,392	6,196
	4.	1,560	7,650	218	4,948	14,376	3,594
	6.	1,560	9,240	235	4,948	15,983	2,664
	7.5	1,560	9,900	246	4,948	16,654	2,220
3	1.	3,360	4,595	197	7,004	15,156	15,156
	2.	3,360	5,680	204	7,004	16,248	8,124
	4.	3,360	7,650	218	7,004	18,232	4,558
	6.	3,360	9,240	235	7,004	19,839	3,307
	7.5	3,360	9,900	246	7,004	20,510	2,735

TABLE 6

SUMMARY OF AVERAGE ANNUAL COSTS -- ALL PLANS
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

PLAN	INSTALLED CAPACITY	TOTAL PROJECT FIRST COST	INTEREST DURING CONSTRUCTION (2x7 3/8%)	TOTAL PROJECT INVESTMENT COST	INTEREST AND AMORTIZATION (FACTOR = 0.07591)	OPERATION & MAINTENANCE (1.2%)	MAJOR REPLACEMENT (0.1%)	TOTAL ANNUAL COST
1	1.	$4,792	$ 708	$ 5,500	$ 418	$ 66	$ 6	$ 490
	2.	5,884	868	6,752	512	81	7	600
	4.	7,868	1,160	9,028	685	108	9	802
	6.	9,475	1,398	10,873	825	130	11	966
	7.5	10,146	1,497	11,643	884	140	12	1,036
1A	1.	7,166	1,057	8,223	624	93	8	725
	2.	8.258	1,218	9,476	719	114	9	842
	4.	10,242	1,511	11,753	892	141	12	1,045
	6.	11,849	1,748	13,597	1,032	163	14	1,209
	7.5	12,520	1,847	14,367	1,091	172	14	1,277
2	1.	9,338	1,377	10,715	813	129	11	953
	2.	10,430	1,538	11,968	908	144	12	1,064
	4.	12,414	1,831	14,245	1,081	171	14	1,266
	6.	14,021	2,068	16,089	1,221	193	16	1,430
	7.5	14,692	2,167	16,859	1,280	202	17	1,499
2A	1.	11,300	1,667	12,967	984	156	13	1,153
	2.	12,392	1,828	14,220	1,079	171	14	1,264
	4.	14,376	2,120	16,496	1,252	198	16	1,466
	6.	15,983	2,357	18,340	1,392	220	18	1,630
	7.5	16,654	2,456	19,110	1,451	229	19	1,699
3	1.	15,156	2,236	17,392	1,320	209	17	1,546
	2.	16,248	2,397	18,645	1,415	224	19	1,658
	4.	18,232	2,689	20,921	1,588	251	21	1,860
	6.	19,839	2,926	22,765	1,728	273	23	2,024
	7.5	20,510	3,025	23,535	1,786	282	24	2,092

TABLE 7
AVERAGE ANNUAL ENERGY - ALL PLANS
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

Installed Capacity (MW)	Average Annual Energy (GWh)			
	4 Hrs	6 Hrs	8 Hrs	10 Hrs
PLAN 1				
1.0			3.2	(All Operations)
2.0			4.6	(All Operations)
4.0			6.5	(All Operations)
6.0			7.2	(All Operations)
7.5			7.6	(All Operations)
PLAN 1A				
1.0			4.2	(All Operations)
2.0			5.5	(All Operations)
4.0			7.5	(All Operations)
6.0			8.1	(All Operations)
7.5			8.1	(All Operations)
PLAN 2				
1.0	5.3	5.3	5.3	5.3
2.0	6.4	6.4	6.4	7.1
4.0	8.2	8.3	7.8	7.8
6.0	9.1	8.0	6.6	6.6
7.5	8.6	6.8	6.5	6.5
PLAN 2A				
1.0	6.0	6.0	6.0	6.4
2.0	7.2	7.2	7.2	8.7
4.0	8.7	9.5	9.2	8.2
6.0	10.2	9.1	8.2	8.1
7.5	9.9	8.3	7.5	8.1
PLAN 3				
1.0	6.7	6.7	6.7	--
2.0	8.1	8.1	8.1	--
4.0	9.2	10.8	10.7	--
6.0	11.4	10.6	9.9	--
7.5	11.2	9.8	8.4	--

TABLE 8
DEPENDABLE CAPACITY - ALL PLANS
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

Installed Capacity (MW)	Dependable Capacity (90% available in Jan)			
PLANS 1 AND 1A				
1			0.6	
2			0.7	
4			0.7	
6			0.7	
7.5			0.7	
PLANS 2 AND 2A	4 HR	6 HR	8 HR	10 HR
1	0.6	0.1	0.1	0.1
2	0.7	0.1	0.1	0.1
4	0.7	0.1	0.1	0.1
6	0.7	0.1	0.1	0.1
7.5	0.7	0.1	0.1	0.1
PLAN 3				
1	0.9	0.7	0.7	--
2	1.0	0.1	0.1	--
4	1.0	0.1	0.1	--
6	1.0	0.1	0.1	--
7.5	1.0	0.1	0.1	--

NOTE: Dependable capacity for Plans No. 1 and 1A is not a function of time time on peak since there is no designated storage to draw from for hydropower.

TABLE 9
GENERALIZED POWER VALUES
ECAR REGION - FEDERAL FINANCING
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

Hydro Capacity Factor	Type Alternative	Capacity Value	Energy Value	Escalated Energy Value
(%)		($/kw-yr)	(mil/kwh)	(mil/kwh)
0	Combustion	38.90		
5	Turbine	25.80	112.9	176.1
10		25.80	72.7	113.4
15		25.80	62.0	96.7
20		25.80	56.1	87.5
30		25.80	49.4	77.1
15	Combined	45.40	85.0	138.6
20	Cycle	45.40	73.7	115.0
25		45.40	66.8	104.2
30		45.40	52.3	97.2
40	Coal	101.10	7.5	10.5
50		101.10	11.5	16.1
60		101.10	14.1	19.7
70		101.10	16.2	22.7
80		101.10	17.2	24.1
90		101.10	17.8	24.9
100		101.10	18.0	25.2

TABLE 10

SUMMARY OF PROJECT BENEFITS - PLANS NO. 1 AND 1A
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY MW	HYDRO CAPACITY FACTOR (%)	REGIONAL POWER VALUES CAPACITY ($/kw)	REGIONAL POWER VALUES ENERGY ($/MWh)	DEPENDABLE CAPACITY (MW)	CAPACITY BENEFIT ($1000/YR)	AV ANN ENERGY (Gwh)	ENERGY BENEFIT ($1000/YR)	TOTAL ANN BENEFITS ($1000/YR)
				PLAN 1				
1.	36.5	25.80	72.0	0.6	15.5	3.2	230.4	245.9
2.	26.2	25.80	80.5	0.7	18.1	4.6	370.3	388.4
4.	18.6	25.80	90.0	0.7	18.1	6.5	585.0	603.1
6.	13.7	25.80	99.4	0.7	18.1	7.2	715.7	733.8
7.5	11.6	25.80	106.0	0.7	18.1	7.6	805.6	823.7
				PLAN 1A				
1.	47.9	101.10	16.1	0.6	60.7	4.2	67.6	128.3
2.	31.4	25.80	76.0	0.7	18.1	5.5	418.0	436.1
4.	21.1	25.80	86.5	0.7	18.1	7.4	640.1	658.2
6.	15.4	25.80	95.0	0.7	18.1	8.1	769.5	787.6
7.5	12.3	25.80	103.0	0.7	18.1	8.1	834.3	852.4

TABLE 11

SUMMARY OF PROJECT BENEFITS - NED OPERATION (4 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY MW	HYDRO CAPACITY FACTOR (%)	REGIONAL POWER VALUES CAPACITY ($/kw)	REGIONAL POWER VALUES ENERGY ($/MWh)	DEPENDABLE CAPACITY (MW)	CAPACITY BENEFITS ($1000/YR)	AV ANN ENERGY (Gwh)	ENERGY BENEFITS ($1000/YR)	TOTAL ANN BENEFITS ($1000/YR)
				PLAN 2				
1.	60.5	101.10	19.7	0.6	60.7	5.3	104.4	165.1
2.	36.6	25.80	72.0	0.7	18.1	6.4	460.8	478.9
4.	23.4	25.80	84.0	0.7	18.1	8.2	688.8	706.9
6.	17.3	25.80	91.5	0.7	18.1	9.1	832.7	850.7
7.5	13.1	25.80	101.0	0.7	18.1	8.6	868.6	886.7
				PLAN 2A				
1.	68.5	101.10	22.7	0.6	60.7	6.0	136.2	196.9
2.	41.1	101.10	10.5	0.7	70.8	7.2	75.6	146.4
4.	24.8	25.80	82.0	0.7	18.1	8.7	713.4	731.5
6.	19.4	25.80	88.2	0.7	18.1	10.2	899.6	917.7
7.5	15.1	25.80	96.6	0.7	18.1	9.9	956.3	974.4
				PLAN 3				
1.	76.5	101.10	24.1	0.9	91.0	6.7	161.5	252.4
2.	76.5	101.10	16.1	1.0	101.1	8.1	130.4	231.5
4.	26.3	25.80	80.5	1.0	25.8	9.2	740.6	766.4
6.	21.7	25.80	86.0	1.0	25.8	11.4	980.4	1006.2
7.5	17.0	25.80	92.0	1.0	25.8	11.2	1030.4	1056.2

TABLE 12

SUMMARY OF PROJECT BENEFITS - EQ OPERATION (10 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY MW	HYDRO CAPACITY FACTOR (%)	REGIONAL POWER VALUES CAPACITY ($/kw)	REGIONAL POWER VALUES ENERGY ($/kw)	DEPENDABLE CAPACITY (MW)	CAPACITY BENEFITS ($1000/YR)	AV ANN ENERGY (Gwh)	ENERGY BENEFITS ($1000/YR)	TOTAL ANN BENEFITS ($1000/YR)
				PLAN 2				
1.	60.5	101.10	19.7	0.1	10.1	5.3	104.4	114.5
2.	40.5	101.10	10.5	0.1	10.1	7.1	74.6	84.7
4.	22.3	25.80	85.0	0.1	2.6	7.8	663.0	665.6
6.	12.6	25.80	102.2	0.1	2.6	6.6	674.5	677.1
7.5	9.9	25.80	113.6	0.1	2.6	6.5	738.4	741.0
				PLAN 2A				
1.	73.1	101.10	22.7	0.1	10.1	6.4	145.2	155.4
2.	49.7	101.10	16.1	0.1	10.1	8.7	140.1	150.2
4.	23.4	25.80	83.8	0.1	2.6	8.2	687.2	689.8
6.	15.4	25.80	95.0	0.1	2.6	8.1	769.5	772.1
7.5	12.3	25.80	103.0	0.1	2.6	8.1	834.3	836.9

TABLE 13

SUMMARY OF PROJECT BENEFITS - TRADE OFF OPERATION (6 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY (MW)	HYDRO CAPACITY FACTOR (%)	REGIONAL POWER VALUES CAPACITY ($/KW)	REGIONAL POWER VALUES ENERGY ($/MWH)	DEPENDABLE CAPACITY (MW)	CAPACITY BENEFIT ($1000/YR)	AV ANN ENERGY (GWH)	ENERGY BENEFIT ($1000/YR)	TOTAL ANN BENEFITS ($1000/YR)
				PLAN 2				
1.	60.5	101.10	19.7	0.1	10.1	5.3	104.4	114.5
2.	36.6	25.80	72.0	0.1	2.6	6.4	460.8	463.4
4.	23.7	25.80	83.0	0.1	2.6	8.3	688.9	691.5
6.	15.2	25.80	96.0	0.1	2.6	8.0	768.0	770.6
7.5	10.4	25.08	109.5	0.1	2.6	6.8	744.6	747.2
				PLAN 2A				
1.	68.5	101.10	22.7	0.1	10.1	6.0	136.2	146.3
2.	41.1	101.10	10.5	0.1	10.1	7.2	75.6	85.7
4.	27.1	25.80	79.8	0.1	2.6	9.5	758.1	760.7
6.	17.3	25.80	91.5	0.1	2.6	9.1	832.7	835.3
7.5	12.6	25.80	102.2	0.1	2.6	8.3	849.3	850.9
				PLAN 3				
1.	76.5	101.10	24.1	0.7	70.8	6.7	161.5	232.3
2.	46.2	101.10	16.1	0.1	10.1	8.1	130.4	140.5
4.	30.8	25.80	76.5	0.1	2.6	10.8	826.2	828.8
6.	20.0	25.80	87.5	0.1	2.6	10.6	927.5	930.1
7.5	14.9	25.80	96.8	0.1	2.6	9.8	948.6	951.2

TABLE 14

SUMMARY OF PROJECT BENEFITS - TRADE OFF OPERATION (8 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY (MW)	HYDRO CAPACITY FACTOR (%)	REGIONAL POWER VALUES		DEPENDABLE CAPACITY (MW)	CAPACITY BENEFIT ($1000/YR)	AV ANN ENERGY (Gwh)	ENERGY BENEFIT ($1000/YR)	TOTAL ANN BENEFITS ($1000/YR)
		CAPACITY ($/KW)	ENERGY ($/MWH)					
				PLAN 2				
1.	60.5	101.10	19.7	0.1	10.1	5.3	104.4	114.5
2.	36.6	25.80	72.0	0.1	2.6	6.4	460.8	463.4
4.	22.3	25.80	85.0	0.1	2.6	7.8	663.0	665.6
6.	12.6	25.80	102.2	0.1	2.6	6.6	674.5	677.1
7.5	9.9	25.08	113.6	0.1	2.6	6.5	738.4	741.0
				PLAN 2A				
1.	68.5	101.10	22.7	0.1	10.1	6.0	136.2	146.3
2.	41.1	101.10	10.5	0.1	10.1	7.2	75.6	85.7
4.	26.3	25.80	80.5	0.1	2.6	9.2	740.6	743.2
6.	15.6	25.80	94.8	0.1	2.6	8.2	777.4	780.0
7.5	11.4	25.80	106.2	0.1	2.6	7.5	796.5	799.1
				PLAN 3				
1.	76.5	101.10	24.1	0.7	70.8	6.7	161.5	232.3
2.	46.2	101.10	16.1	0.1	10.1	8.1	130.4	140.5
4.	30.5	25.80	76.4	0.1	2.6	10.7	817.5	820.1
6.	18.8	25.80	89.5	0.1	2.6	9.9	886.0	888.6
7.5	12.8	25.80	101.5	0.1	2.6	8.4	852.6	855.2

TABLE 15

SUMMARY OF PROJECT ECOMOMICS - PLANS NO. 1 AND 1A
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY (MW)	TOTAL PROJECT FIRST COST ($1,000)	TOTAL ANN COST ($1,000/YR)	TOTAL ANN BENEFITS ($1,000/YR)	NET ANN BENEFITS ($1,000/YR)	BENEFIT/COST RATIO
PLAN 1					
1.	4,759	585	245.9	-339.1	0.4
2.	5,850	597	388.4	-208.6	0.6
4.	7,832	799	603.1	-195.9	0.75
6.	9,436	963	733.8	-229.3	0.76
7.5	10,105	1,031	823.7	-207.3	0.80
PLAN 1A					
1.	7,166	725	128.3	-596.7	0.2
2.	8,258	842	436.1	-405.9	0.5
4.	10,242	1,045	658.2	-386.8	0.6
6.	11,849	1,209	787.6	-421.4	0.6
7.5	12,520	1,277	852.4	-424.6	0.7

TABLE 16

SUMMARY OF PROJECT ECONOMICS - NED OPERATION (4 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY (MW)	TOTAL PROJECT FIRST COST ($1,000)	TOTAL ANN COST ($1,000/YR)	TOTAL ANN BENEFITS ($1,000/YR)	NET ANN BENEFITS ($1,000/YR)	BENEFIT/COST RATIO
		PLAN 2			
1.	9,338	953	165.1	-787.9	0.2
2.	10,430	1,064	478.9	-585.1	0.4
4.	12,414	1,266	706.9	-559.1	0.6
6.	14,021	1,430	850.7	-579.3	0.6
7.5	14,692	1,499	886.7	-612.3	0.6
		PLAN 2A			
1.	11,300	1,153	196.9	-956.1	0.2
2.	12,392	1,264	146.4	-1,117.6	0.1
4.	14,376	1,466	731.5	-734.5	0.5
6.	15,983	1,630	917.7	-712.3	0.6
7.5	16,654	1,699	974.4	-742.7	0.6
		PLAN 3			
1.	15,156	1,546	252.4	-1,253.6	0.2
2.	16,248	1,658	231.5	-1,426.5	0.1
4.	18,232	1,860	766.4	-1,093.6	0.4
6.	19,839	2,024	1,006.2	-1,017.8	0.5
7.5	20,510	2,092	1,056.2	-1,035.8	0.5

TABLE 17

SUMMARY OF PROJECT ECONOMICS - NED OPERATION (10 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY (MW)	TOTAL PROJECT FIRST COST ($1,000)	TOTAL ANN COST ($1,000/YR)	TOTAL ANN BENEFITS ($1,000/YR)	NET ANN BENEFITS ($1,000/YR)	BENEFIT/COST RATIO
		PLAN 2			
-1.	9,338	953	114.5	-838.5	0.1
2.	10,430	1,064	84.7	-979.3	0.1
4.	12,414	1,266	665.6	-600.4	0.5
6.	14,021	1,430	677.1	-752.9	0.5
7.5	14,692	1,499	741.0	-758.0	0.5
		PLAN 2A			
1.	11,300	1,153	155.4	-997.6	0.1
2.	12,392	1,264	150.2	-1,113.8	0.1
4.	14,376	1,466	689.8	-776.2	0.5
6.	15,983	1,630	772.1	-776.2	0.5
7.5	16,654	1,699	836.9	-862.1	0.5

TABLE 18

SUMMARY OF PROJECT ECONOMICS - TRADE OFF OPERATION (6 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

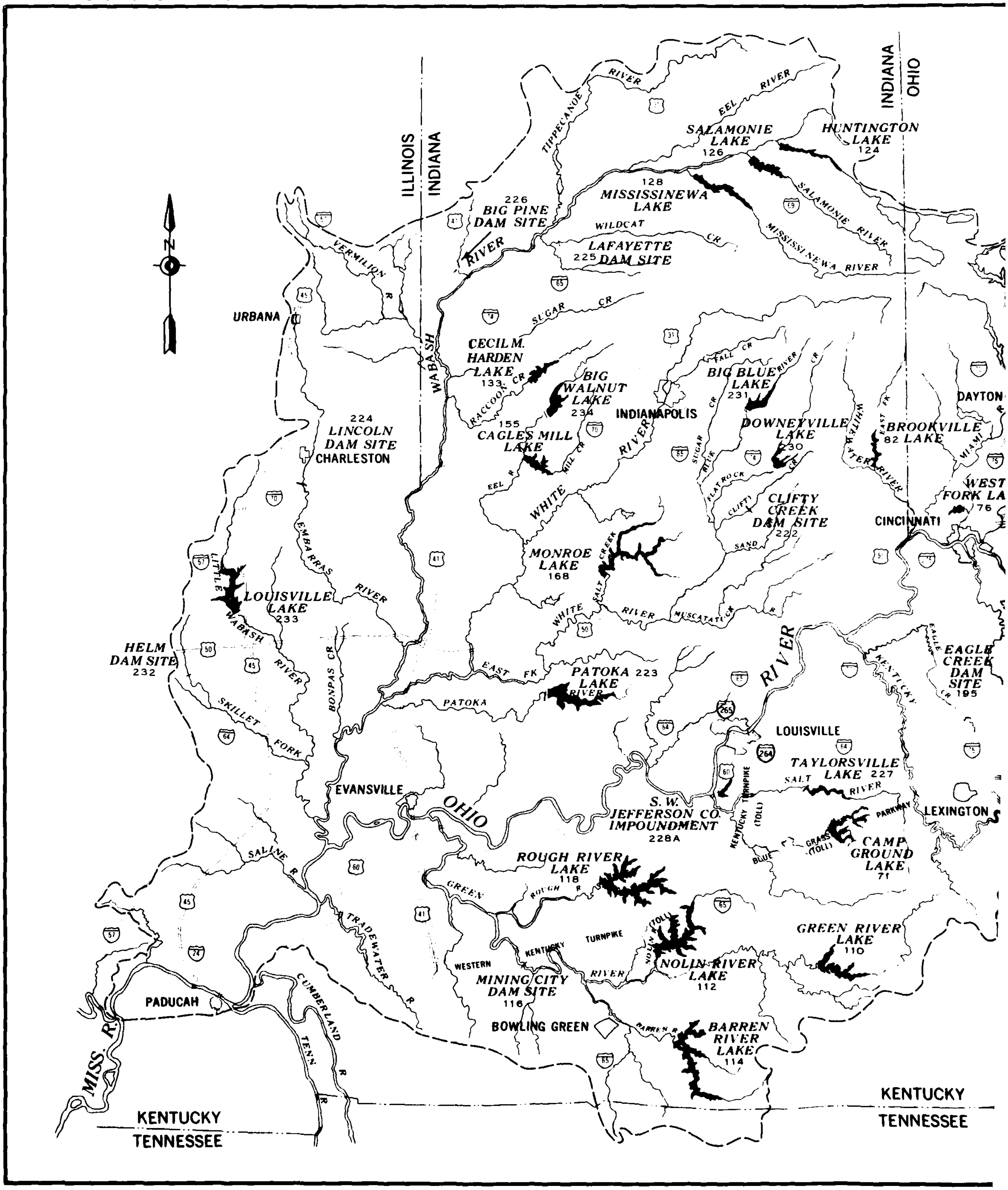
INSTALLED CAPACITY (MW)	TOTAL PROJECT FIRST COST ($1,000)	TOTAL ANN COST ($1,000/YR)	TOTAL ANN BENEFITS ($1,000/YR)	NET ANN BENEFITS ($1,000/YR)	BENEFIT/COST RATIO
		PLAN 2			
1.	9,338	953	114.5	-838.5	0.1
2.	10,430	1,064	463.4	-600.6	0.4
4.	12,414	1,266	691.5	-574.5	0.6
6.	14,021	1,430	770.6	-659.4	0.5
7.5	14,692	1,499	747.2	-751.8	0.5
		PLAN 2A			
1.	11,300	1,153	146.3	-1,006.7	0.1
2.	12,392	1,264	85.7	-1,178.3	0.1
4.	14,376	1,466	760.7	-705.3	0.5
6.	15,983	1,630	835.3	-794.7	0.5
7.5	16,654	1,699	850.9	-848.1	0.5
		PLAN 3			
1.	15,156	1,546	232.3	-1,313.7	0.2
2.	16,248	1,658	140.5	-1,518.5	0.1
4.	18,232	1,860	828.8	-1,031.2	0.5
6.	19,839	2,024	930.1	-1,093.9	0.5
7.5	20,510	2,092	951.2	-1,140.8	0.5

TABLE 19

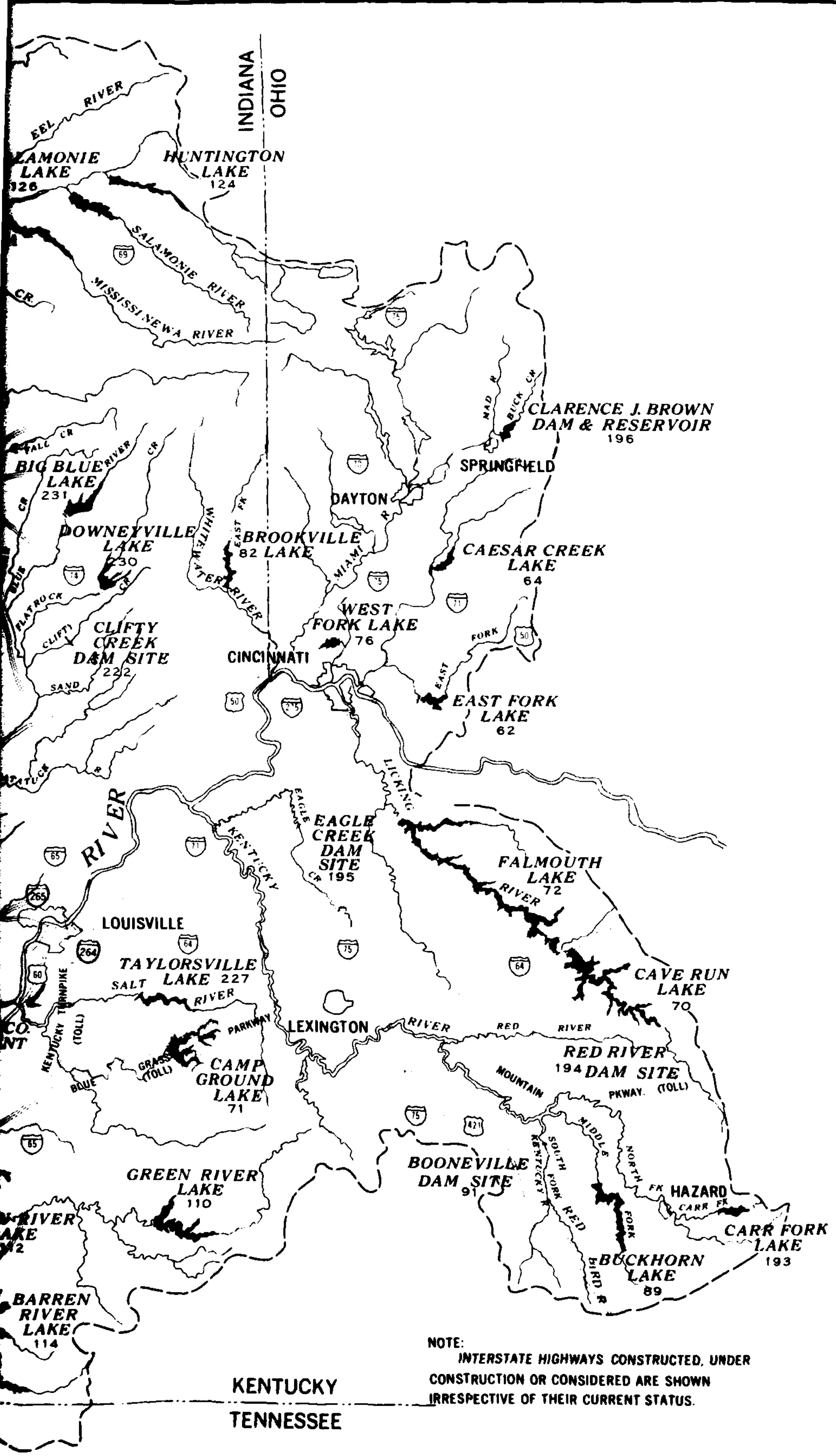
SUMMARY OF PROJECT ECONOMICS - TRADE OFF OPERATION (8 HOURS)
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

INSTALLED CAPACITY (MW)	TOTAL PROJECT FIRST COST ($1,000)	TOTAL ANN COST ($1,000/YR)	TOTAL ANN BENEFITS ($1,000/YR)	NET ANN BENEFITS ($1,000/YR)	BENEFIT/COST RATIO
		PLAN 2			
1.	9,338	953	114.5	-738.5	0.1
2.	10,430	1,064	463.4	-600.6	0.4
4.	12,414	1,266	665.6	-600.4	0.5
6.	14,021	1,430	677.1	-752.9	0.5
7.5	14,691	1,499	741.0	-758.0	0.5
		PLAN 2A			
1.	11,300	1,153	146.3	-1,006.7	0.1
2.	12,392	1,264	85.7	-1,178.3	0.1
4.	14,376	1,466	743.2	-722.8	0.5
6.	15,983	1,630	780.0	-850.0	0.5
7.5	16,654	1,699	799.1	-899.9	0.5
		PLAN 3			
1.	15,156	1,546	232.2	-1,313.7	0.2
2.	16,248	1,658	140.5	-1,517.5	0.1
4.	18,232	1,860	820.1	-1,039.9	0.4
6.	19,839	2,024	888.6	-1,135.4	0.4
7.5	20,510	2,092	855.2	-1,236.2	0.4

CORPS OF ENGINEERS



U. S. ARMY F/C 54



NOTE:
INTERSTATE HIGHWAYS CONSTRUCTED, UNDER CONSTRUCTION OR CONSIDERED ARE SHOWN IRRESPECTIVE OF THEIR CURRENT STATUS.

PROJECT KEY

62	EAST FORK LAKE
64	CAESAR CREEK LAKE
70	CAVE RUN LAKE
71	CAMP GROUND LAKE
72	FALMOUTH LAKE
76	WEST FORK OF MILL CREEK LAKE
82	BROOKVILLE LAKE
89	BUCKHORN LAKE
91	BOONEVILLE LAKE
110	GREEN RIVER LAKE
112	NOLIN RIVER LAKE
114	BARREN RIVER LAKE
116	MINING CITY LAKE
118	ROUGH RIVER LAKE
124	HUNTINGTON LAKE
126	SALAMONIE LAKE
128	MISSISSINEWA LAKE
133	CECIL M HARDEN LAKE
155	CAGLES MILL LAKE
168	MONROE LAKE
193	CARR FORK LAKE
194	RED RIVER LAKE
195	EAGLE CREEK LAKE
196	CLARENCE J. BROWN DAM & RESERVOIR
222	CLIFTY CREEK LAKE
223	PATOKA LAKE
224	LINCOLN LAKE
225	LAFAYETTE LAKE
226	BIG PINE LAKE
227	TAYLORSVILLE LAKE
230	DOWNEYVILLE LAKE
231	BIG BLUE LAKE
232	HELM LAKE
233	LOUISVILLE LAKE
234	BIG WALNUT LAKE
228A	SOUTHWEST JEFFERSON COUNTY IMPOUNDMENT

LEGEND

COMPLETED
UNDER CONSTRUCTION
AUTHORIZED

MULTIPLE PURPOSE PROJECTS

INDEX MAP

LOUISVILLE, KY. DISTRICT

SCALE IN MILES

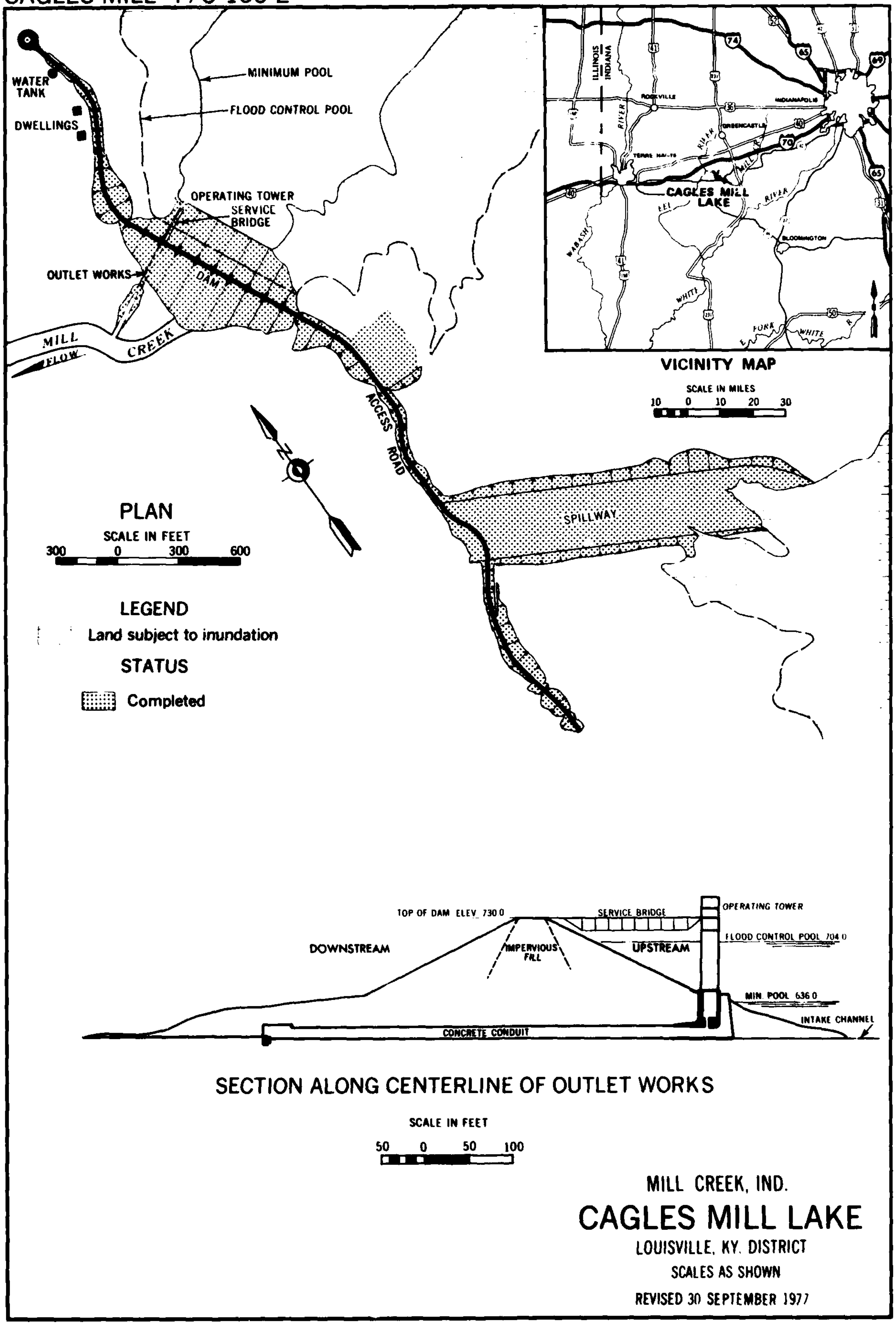
10 0 10 30 50

REVISED 30 SEPTEMBER 1979

2755

AERIAL VIEW OF PROJECT

CAGLES MILL F/C 155-2



CAGLES MILL LAKE, INDIANA

Condition of Improvement, 30 September 1979

LOCATION: The damsite is 2.8 miles above the mouth of Mill Creek, a tributary of Eel River in Putnam County, Indiana, approximately 25 miles east of Terre Haute, Indiana.

AUTHORIZATION: General authorization for the Ohio River Basin is contained in the Flood Control Act of 28 June 1938 (Public Law 761, 75th Congress, 3rd Session).

PROJECT FEATURES: The lake operates primarily for flood control in the Eel and White River Basins, but is also an integral unit of the comprehensive flood control plan for the Lower Wabash, Ohio and Mississippi Rivers.

MULTIPLE-PURPOSE PROJECT:
Counties affected: Putnam and Owen Counties, Indiana.

Operating Levels

Pool	Elevation of Pool	Capacity (acre-feet)	Area (acres)	Backwater Main Stream (length-mile)
Minimum	636	27,100	1,400	10
Flood Control	636-704	201,000	4,840	10-11
Total Storage	704	228,100	4,840	11

Drainage area above dam - 295 square miles.

Dam: Earth embankment 900 feet in length and a maximum height of 150 feet.

Spillway: Uncontrolled open cut spillway 285 feet wide, through the left abutment about 1,900 feet south of dam, with crest elevation 704' and design capacity of 75,700 cfs.

Outlet Works: Intake structure with three hydraulically operated 5' x 10' gates, and a 30-inch low flow bypass pipe all discharging to a concrete horseshoe conduit 12 feet in diameter, running through the right abutment to a flip bucket basin.

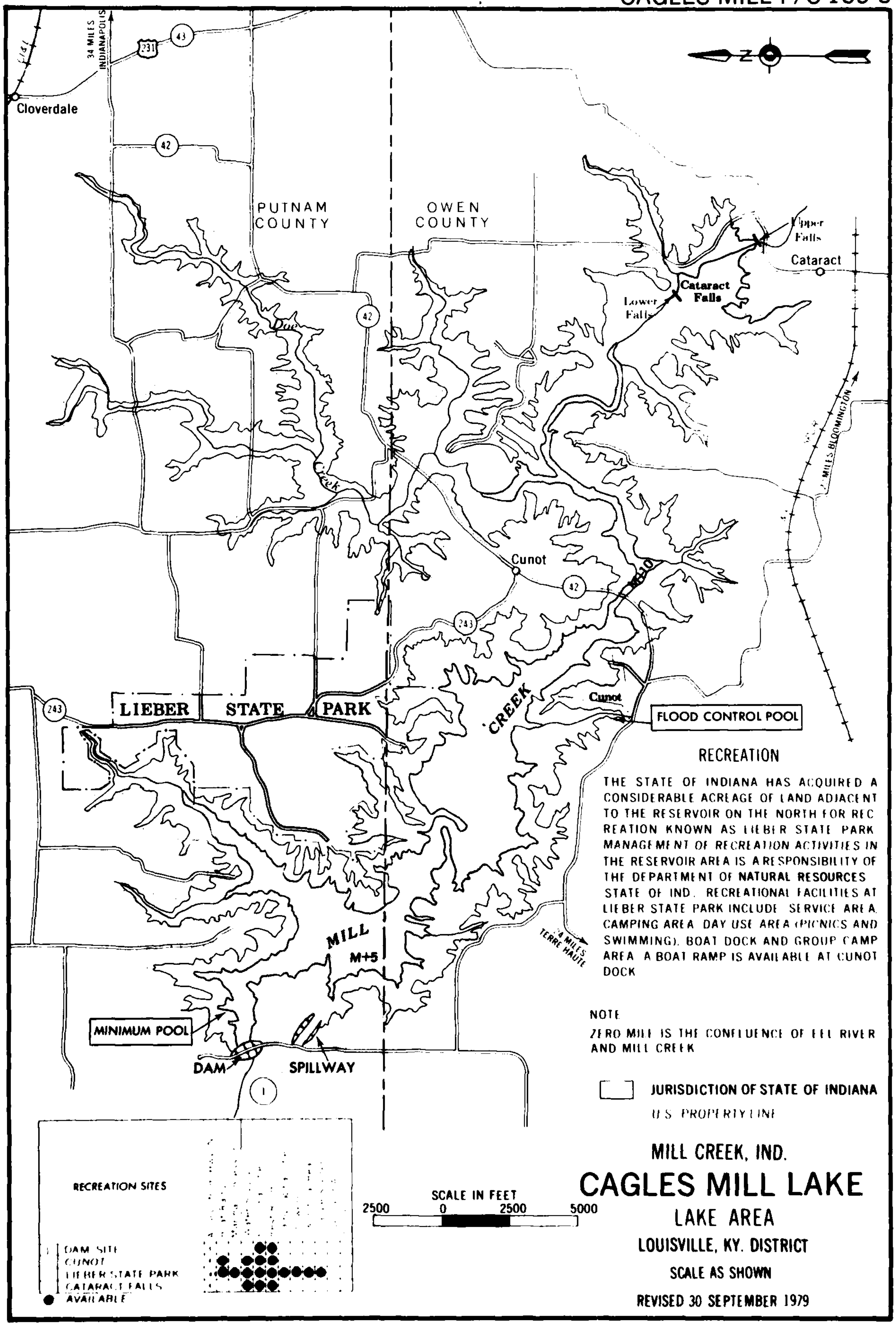
Relocation: Relocations comprise three cemeteries having a total of 62 graves, 1.25 miles of state highway, one bridge and 1.6 miles of pipeline.

Land: U.S. property 7,249.75 acres (fee) and 9.1 acres (flowage easement).

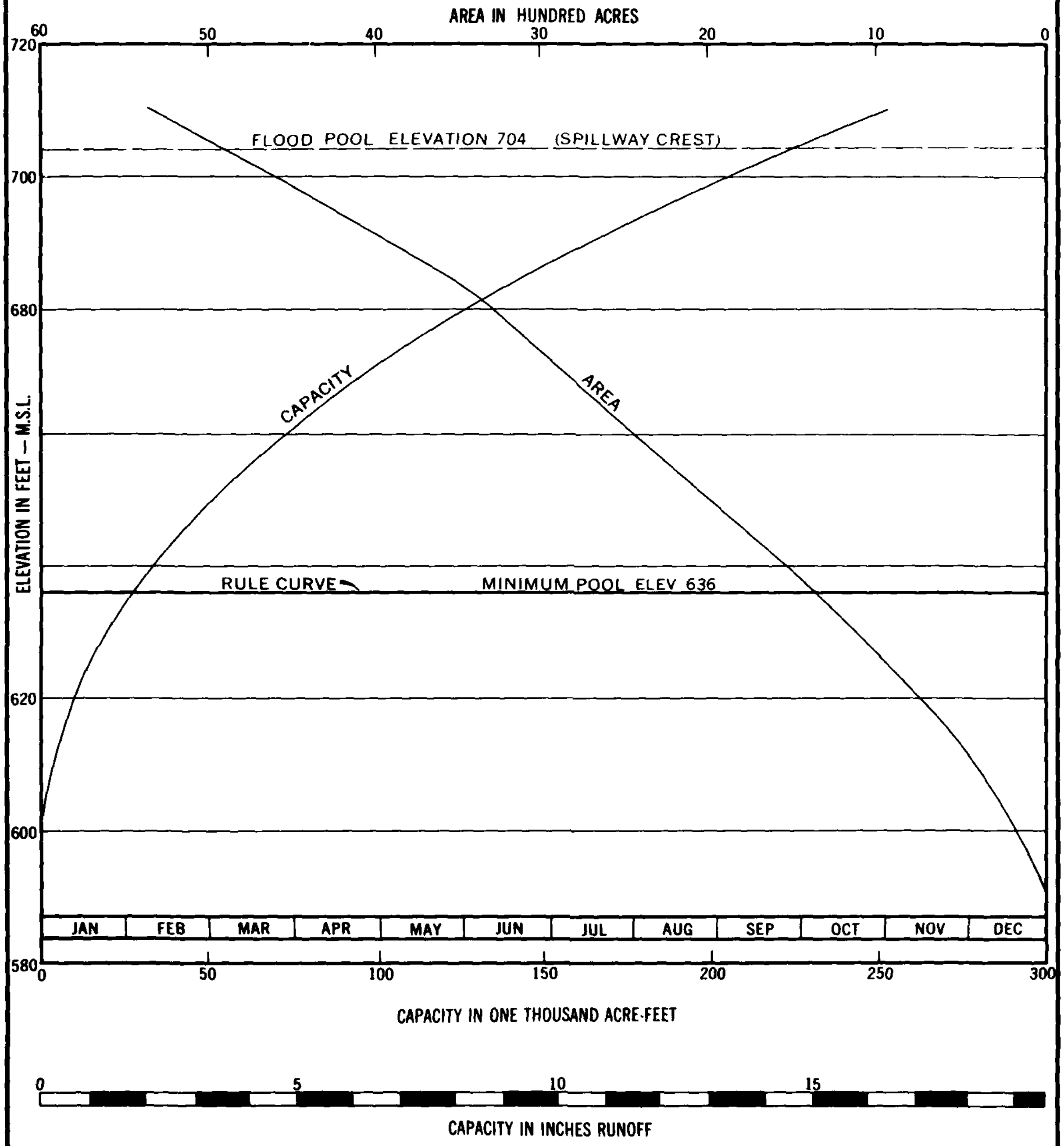
PROGRESS: Construction started July 1948 and completed June 1953.

COST DATA:

Estimated Federal Cost (1976)	$4,255,800
Estimated Nonfederal Cost (1976)	-0-
Estimated Project Cost (1976)	4,255,800
Federal Costs to 30 September 1976	4,143,600
Federal Net Allotments to 30 September 1976	4,143,600


34 MILES INDIANAPOLIS
Cloverdale
231
43
42
PUTNAM COUNTY
OWEN COUNTY
Upper Falls
Cataract
Cataract Falls
Lower Falls
Doe Creek
Cunot
42
243
LIEBER STATE PARK
243
CREEK
Cunot
FLOOD CONTROL POOL
MILES BLOOMINGTON
MILL
M+5
MILES TERRE HAUTE
MINIMUM POOL
DAM
SPILLWAY
1
RECREATION
THE STATE OF INDIANA HAS ACQUIRED A CONSIDERABLE ACREAGE OF LAND ADJACENT TO THE RESERVOIR ON THE NORTH FOR RECREATION KNOWN AS LIEBER STATE PARK MANAGEMENT OF RECREATION ACTIVITIES IN THE RESERVOIR AREA IS A RESPONSIBILITY OF THE DEPARTMENT OF NATURAL RESOURCES STATE OF IND. RECREATIONAL FACILITIES AT LIEBER STATE PARK INCLUDE SERVICE AREA, CAMPING AREA DAY USE AREA (PICNICS AND SWIMMING), BOAT DOCK AND GROUP CAMP AREA A BOAT RAMP IS AVAILABLE AT CUNOT DOCK
NOTE
ZERO MILE IS THE CONFLUENCE OF EEL RIVER AND MILL CREEK
JURISDICTION OF STATE OF INDIANA
U.S. PROPERTY LINE
RECREATION SITES
DAM SITE
CUNOT
LIEBER STATE PARK
CATARACT FALLS
AVAILABLE
SCALE IN FEET
2500 0 2500 5000
MILL CREEK, IND.
CAGLES MILL LAKE
LAKE AREA
LOUISVILLE, KY. DISTRICT
SCALE AS SHOWN
REVISED 30 SEPTEMBER 1979

CAGLES MILL F/C 155-6



MILL CREEK, IND.

CAGLES MILL LAKE

POOL AND OPERATING DATA

LOUISVILLE, KY. DISTRICT

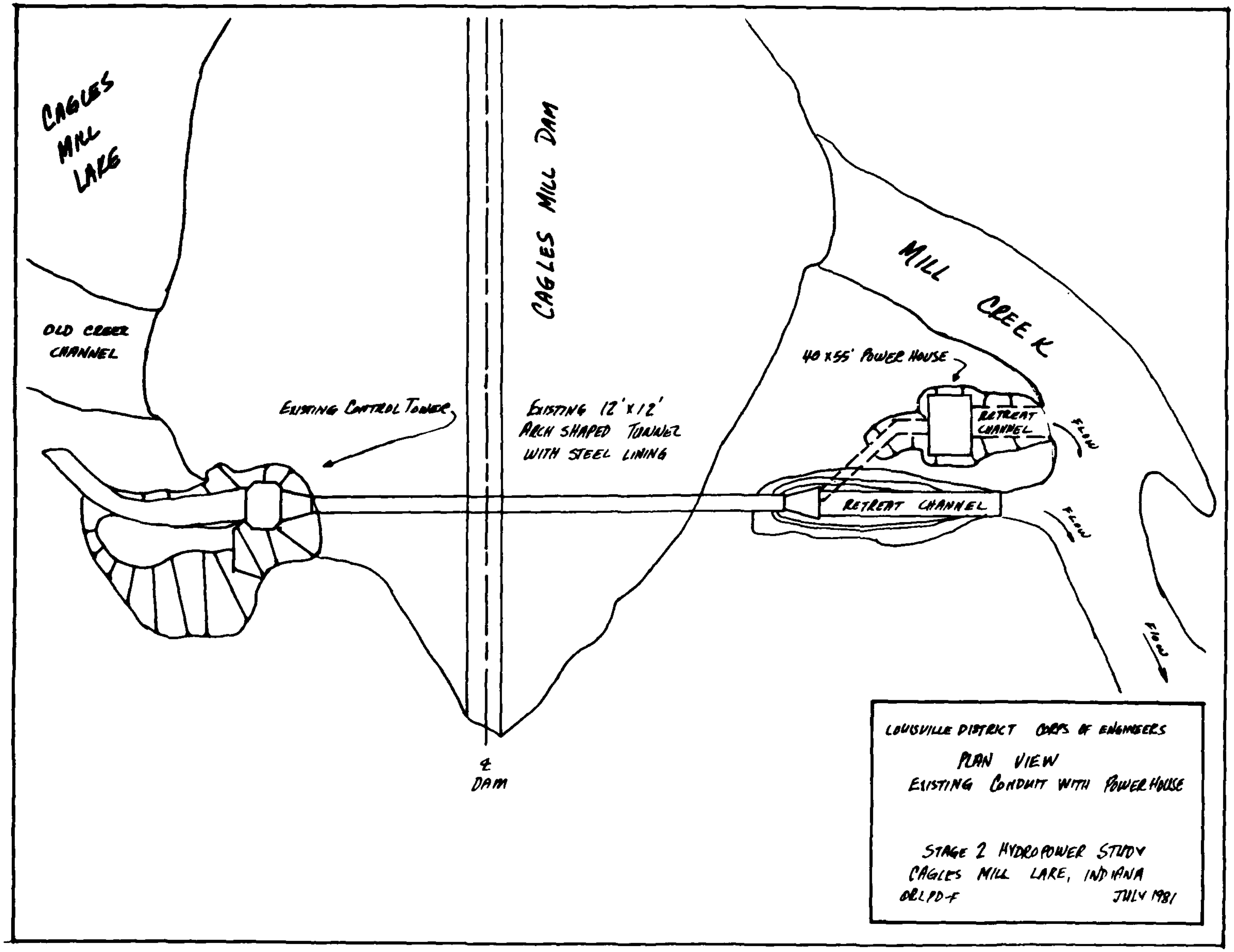
SCALES AS SHOWN

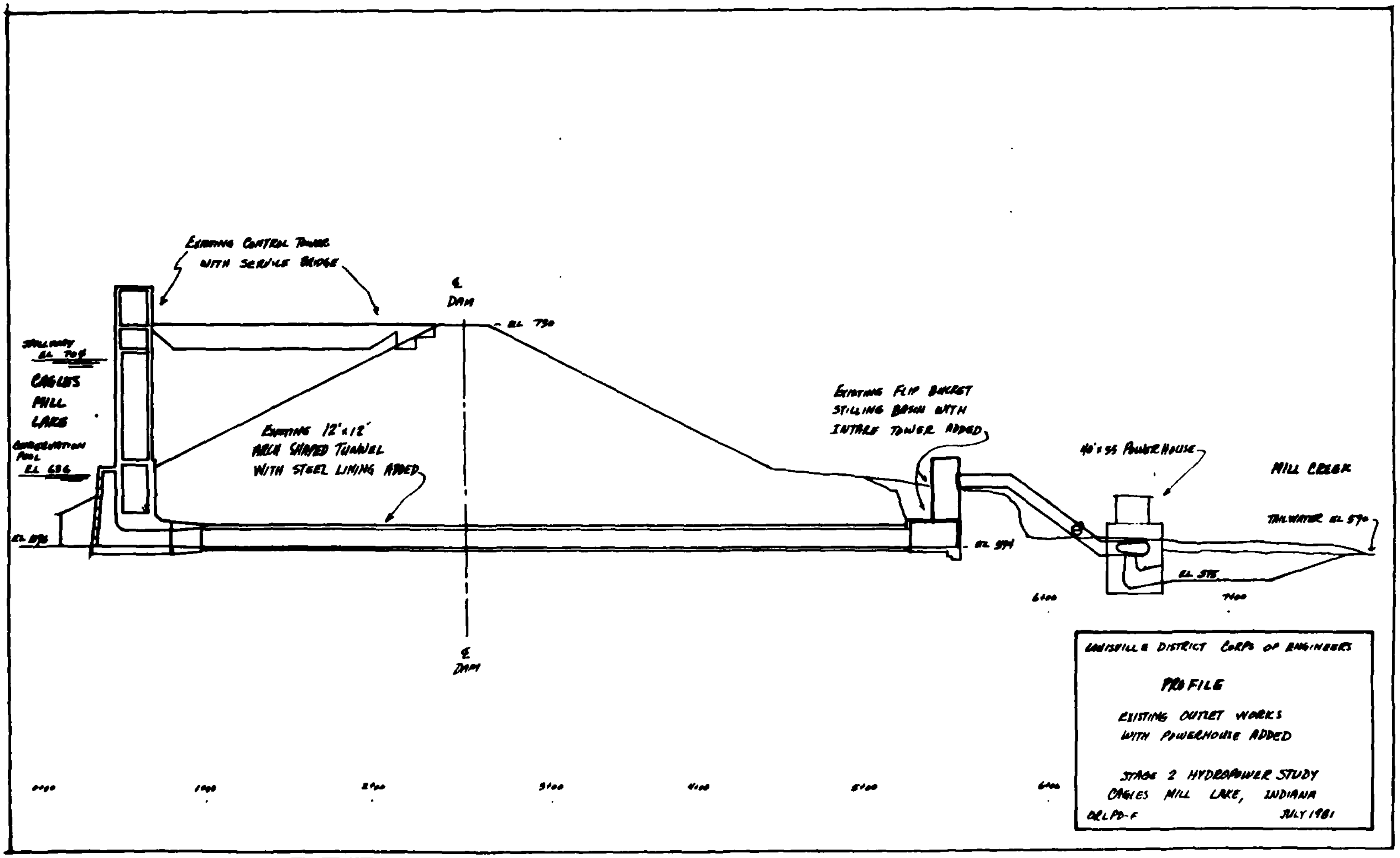
REVISED 30 JUNE 1972

OPERATING RELEASES

MAXIMUM RATE: 4,000 C.F.S.

MINIMUM RATE: Inflows up to a maximum of 100 C.F.S.


CAGLES MILL LAKE
OLD CREEK CHANNEL
CAGLES MILL DAM
EXISTING CONTROL TOWER
EXISTING 12'x12' ARCH SHAPED TUNNEL WITH STEEL LINING
℄ DAM
MILL CREEK
40x55' POWER HOUSE
RETREAT CHANNEL
RETREAT CHANNEL
FLOW
FLOW
FLOW
LOUISVILLE DISTRICT CORPS OF ENGINEERS
PLAN VIEW
EXISTING CONDUIT WITH POWER HOUSE
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA
ORLPD-F
JULY 1981



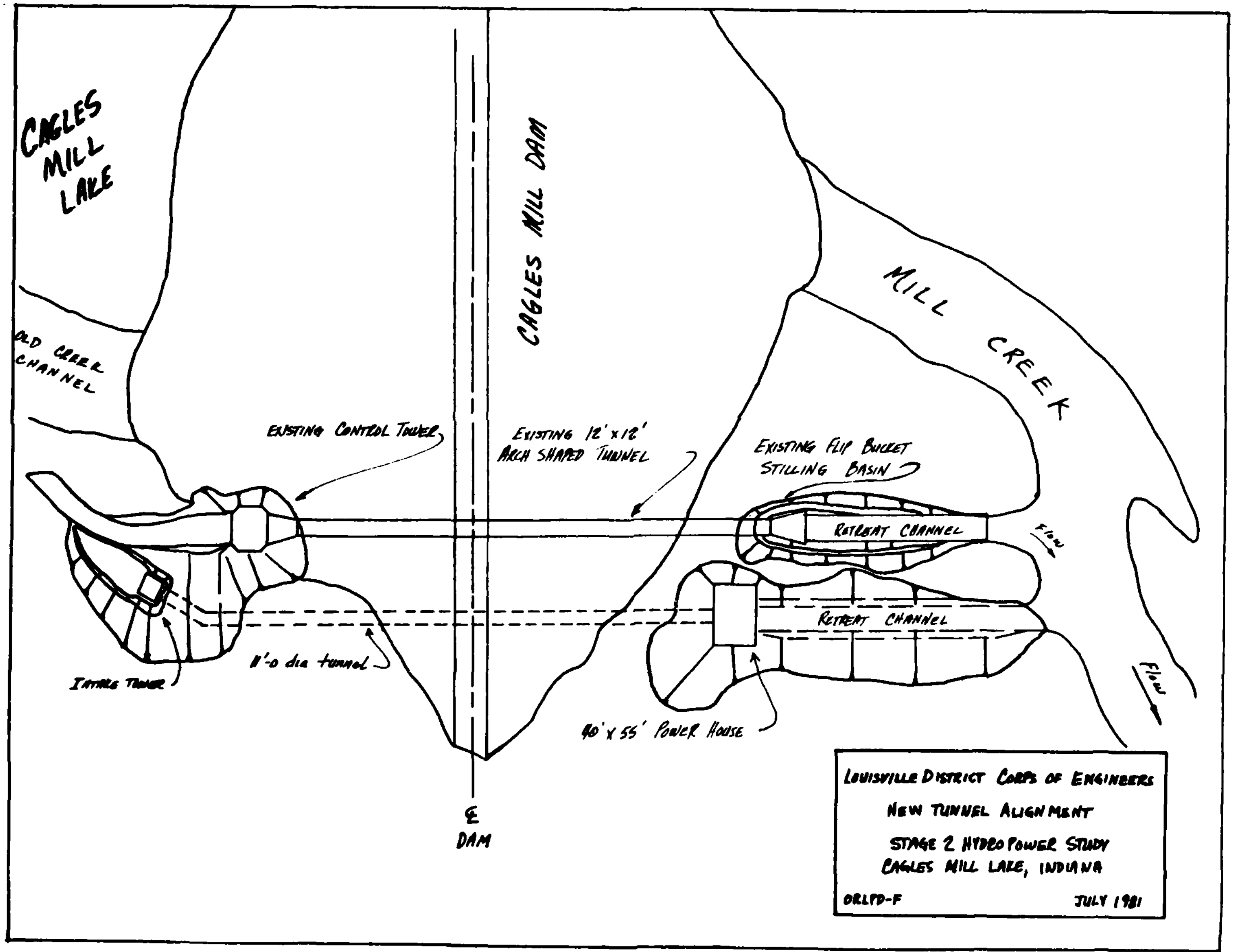
LOUISVILLE DISTRICT CORPS OF ENGINEERS

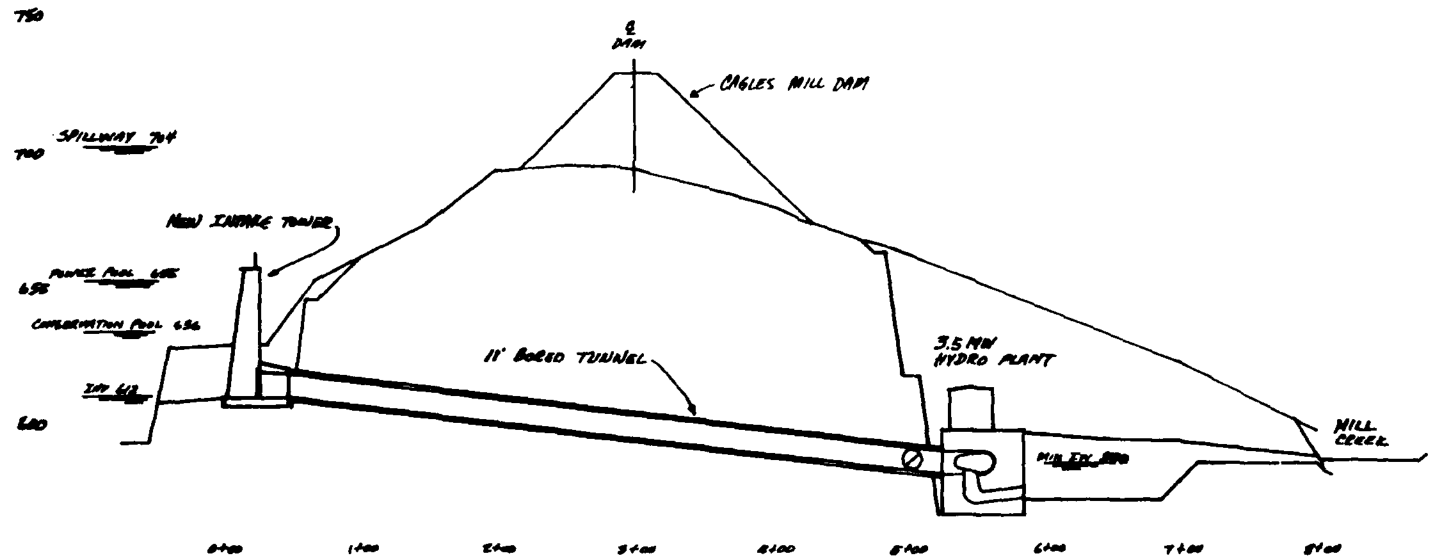
PROFILE

EXISTING OUTLET WORKS
WITH POWERHOUSE ADDED

STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA

ORLPD-F JULY 1981


CAGLES MILL LAKE
OLD CREEK CHANNEL
CAGLES MILL DAM
MILL CREEK
EXISTING CONTROL TOWER
EXISTING 12'x12' ARCH SHAPED TUNNEL
EXISTING FLIP BUCKET STILLING BASIN
RETREAT CHANNEL
FLOW
RETREAT CHANNEL
FLOW
INTAKE TOWER
11'-0 dia tunnel
℄ DAM
40'x 55' POWER HOUSE
LOUISVILLE DISTRICT CORPS OF ENGINEERS
NEW TUNNEL ALIGNMENT
STAGE 2 HYDROPOWER STUDY
CAGLES MILL LAKE, INDIANA
ORLPD-F
JULY 1981



LOUISVILLE DISTRICT CORPS OF ENGINEERS

PROFILE

NEW TUNNEL ALIGNMENT

STAGE 2 HYDROPOWER STUDY

CAGLES MILL LAKE, INDIANA

ORLPD-F JULY 1981

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